Available online at www.sciencedirect.com
ScienceDirect
Procedia Engineering 111 (2015) 803 – 806
Procedia Engineering
www.elsevier.com/locate/procedia

XXIV R-S-P seminar, Theoretical Foundation of Civil Engineering (24RSP) (TFoCE 2015)

Degradation model of wear frogs switches on the track ŽSR

Ján Urda[a], Ján Mandulab, Anastázia Urdová[c*]

[a]*Railways of the Slovak Republic, Research and Development Institute of Railways in Žilina, Hviezdoslavova 31, 010 02 Žilina, Slovakia*
[b]*Technical university of Košice, Civil Engineering Faculty, Vysokoškolská 4, 042 00 Košice, Slovakia*
[c]*University of Žilina, Faculty of Civil Engineering, Univerzitná 8215/1, 010 26 Žilina, Slovakia*

Abstract

This paper deals with the measurement and evaluation of wear frogs switches ZSR. One of the main problems is the oversize wear. The possibilities analysis of this problem is offered through a set of switches and monitoring of selected parameters. One of these parameters is also monitoring the vertical wear.

Peer-review under responsibility of organizing committee of the XXIV R-S-P seminar, Theoretical Foundation of Civil Engineering (24RSP)

Keywords: Switches; Crossing; Nose of crossing; Vertical wear; Correlation analysis; Regression analysis.

1. Introduction

The basic and important condition for effective management and maintenance of traffic road recognition of its real condition. The way to this knowledge is a system of measurement, monitoring and diagnostics traffic road [1].

One of the methods of diagnosis of switches also measure the wear of mobile components, mainly switch blade and frogs. Oversize wear frogs mainly on modernized sections of line ZSR is becoming an increasing problem in relation to the manufacturer for unrecognized claim.

So Research and Development Institute of railways in Žilina was given the task of monitoring the 40 pieces of frogs on network of ŽSR in periphery OR Trnava circuit for five years.

The measurements began in May 2012 and continues today. While measurements were carried out in 7 stages at intervals of 0, 4, 12, 16, 24, 28 and 36 months. He used the laser device to measure the rail profile CONTOUR.

In view to the limited range this paper, will be dealt with only vertical wear of frogs switches. According to valid regulations ZSR TS 3 Track superstructure is a service leader most vertical wear a frog in a place where the wedge width is 40 mm and larger, the speed limit:

- $V \geq 100$ km/h, max. 6 mm,
- 40 km/h < V < 100 km/h, max. 9 mm,
- $V \leq 40$ km/h, max. 12 mm.

The values of the vertical wear frog are measured in the longitudinal direction as the difference flowline of wing rails and the measuring point of the nose of crossing, which is the width of 40 mm, see Fig. 1.

* Corresponding autor. Tel. 00420 41 513 5860
E-mail address: anastazia.urdova@fstav.uniza.sk

Peer-review under responsibility of organizing committee of the XXIV R-S-P seminar, Theoretical Foundation of Civil Engineering (24RSP)
doi:10.1016/j.proeng.2015.07.149

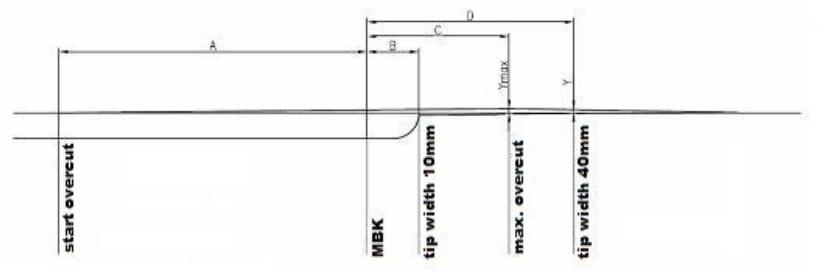

Fig. 1 Longitudinal section nose of crossing.

2. Mathematical and statistical methods of derivation of the model

Summary of mathematical statistical evaluation is to determine a suitable model of the degradation vertical wear frogs and examining possible links between the monitored variables. Of the basic mathematical and statistical methods were used:

- method of descriptive statistics,
- method of regression analysis,
- method of correlation analysis.

2.1. Multiple linear regression analysis of the model

The relationship between the dependent variable - vertical wear frogs y and independent variable x_i is estimated by multiple linear regression model [3]:

$$y = a_0 + a_1 x_1 + a_2 x_2 + a_3 x_3 + a_4 x_4 + a_5 x_5 + a_6 x_6 \tag{1}$$

where:
x_1 - speed in the diverging track direction (km/h),
x_2 - construction length of switches (m),
x_3 - the width of the rail profile (mm),
x_4 - transformation switches (single, x_4=1; curved, x_4=2),
x_5 - type of crossing (common crossing, x_5=1; movable spring nose, x_5=2),
x_6 - time of operation (0, 4, 12, 16, 24, 28, 36 months),

Estimation of the regression coefficients a_i (i = 0, 1, 2,...6) has been carried out by the method of least squares.
In a multiple linear regression model was also tested hypothesis significance, suitability regression model. In testing it is assumed that the error ε are independent and have a normal distribution. The hypothesis of the significance of the model can be formulated as follows [3]:

$$H_0 : a_i = 0 \tag{2}$$

compared to the alternative hypothesis:

$$H_0 : \text{at least one of the coefficients } a_i \neq 0 \tag{3}$$

When considering the linear regression model was tested:

- Hypothesis (H) of significance of the model,
  $H_0 : a_i = 0$ compared to the alternative hypothesis: H_0 : at least one of the coefficients $a_i \neq 0$.

Hypotheses were tested using Fisher distribution inequality that for a finite number of regression coefficients used in the model (1) takes the form:

$$F = 2{,}880 > F_{0,05} = 2{,}170 \tag{4}$$

From the inequality shows that the hypothesis $H_0 : a_i = 0$ is rejected and the regression coefficients, or a few, can be seen on the surface of the test α = 0,05 for non-zero.

- Hypothesis (H), the transfer of the variable x_i in the model, which already contains all the variables:
  $H_0 : a_i = 0$ compared to the alternative hypothesis: $H_0 : a_i \neq 0$.

To test was used characteristics with the Student t-distribution:

$$t_i = \frac{|b_i|}{S_{bi}} > t_{0,05}(120-6-1) = 1{,}91 \tag{5}$$

where:

S_{bi} - standard deviation of the regression coefficients b_i.

Test results are shown in Table 1, from which we can conclude that the deposit is not all selected variables in the proposed of the model the degradation wear a frog (1) is significant.

Table 1. Test the regression coefficients of the degradation of the model (1).

Value	Unit	Regression coefficients a_i	$\lvert t_i \rvert$		$t_{0,05}$
-	(-)	-0,05028	0,05726	<	1,91
x_1	(km/h)	0,001295	0,165126	<	1,91
x_2	(m)	-0,00041	0,03312	<	1,91
x_3	(mm)	0,001024	0,084295	<	1,91
x_4	(-)	0,114526	1,910637	>	1,91
x_5	(-)	-0,04503	0,74199	<	1,91
x_6	(months)	0,005889	3,252068	>	1,91

2.2. Correlation analysis of the model

The existence of correlation links between the variables being monitored has been evaluated pairwise Pearson correlation coefficients. These can be written in matrix form. The determinant of the correlation matrix |R| and expanded matrix determinant |R*| takes the form:

$$R = \begin{bmatrix} 1 & R_{x_1x_2} & \cdots & R_{x_1x_6} \\ R_{x_1x_2} & 1 & \cdots & R_{x_2x_6} \\ \vdots & & & \\ R_{x_1x_6} & R_{x_2x_6} & \cdots & 1 \end{bmatrix} \qquad R^* = \begin{bmatrix} R_{y\,x_1} & R_{y\,x_2} & \cdots & R_{y\,x_6} & 0 \\ 1 & R_{x_1x_2} & \cdots & r_{x_1x_6} & R_{y\,x_1} \\ R_{x_1x_2} & 1 & \cdots & R_{x_2x_6} & R_{y\,x_2} \\ \vdots & & & & \\ R_{x_1x_6} & R_{x_2x_6} & \cdots & 1 & R_{y\,x_6} \end{bmatrix} \tag{6}$$

The coefficient of multiple correlation, indicating a result of the combined action of the variables x_i (i = 1, 2,...6) on the dependent variable y then expressed by the expression:

$$R_{y \cdot x_1\,x_2\,x_3\,x_4\,x_5\,x_6} = \sqrt{\frac{|R^*|}{|R|}} = 0{,}3642 \tag{7}$$

Test results are shown in Table 2.

Table 2. Test partial correlation coefficients of the degradation of the model (1).

Value	Unit	Regression coefficients a_i	$\lvert R_{y,\,xi} \rvert$		$R_{critical,\ \alpha=0,05}$
x_1	(km/h)	0,001295	0,128903	<	0,178
x_2	(m)	-0,00041	0,133318	<	0,178
x_3	(mm)	0,001024	0,066660	<	0,178
x_4	(-)	0,114526	0,178212	>	0,178
x_5	(-)	-0,04503	0,014960	<	0,178
x_6	(months)	0,005889	0,284920	>	0,178
y	(mm)	-	0,364186	>	0,178

3. Conclusion

From the results shown in Table 1 and 2, we conclude that the degradation model (1) can be considered the significance level α = 0,05 satisfactory.

Test results show that a statistically significant effect on the wear frog switches have their period of operation and the fact that the switches in the track laid in primary forms or transformed. By contrast, the other, the model included independent variables are not yet appear to be statistically significant.

It should be pursued to extend the set of additional measurements. It is then possible to work with a larger set of measurements and also to deal with other mathematical models, and examine the relationship between wear and working load switches. Therefore, monitoring of these switches will continue.

Acknowledgements

This paper was created with the support of the Operational Programme Research and Development for the project: University Science Park TECHNICOM for innovative applications with support for knowledge technologies, code ITMS: 26220220182, co-financed from the European Regional Development Fund.

References

[1] C. Esveld, Modern railway track, Second edition, Delft University of Technology, Netherlands, 2001.
[2] B. Lichtberger, Track compendium, Eurailpress Tetzlaff-Hestra GmbH & Co. KG, 2005.
[3] Cs. Tőrők, Introduction to probability theory and mathematical statistics, Svf, Košice, 1992.
[4] J. Urda, J. Mandula, A. Urdová, Measurement and evaluation of wear frogs switches ŽSR. Civil and evironmental engineering. roč. 10, č. 1 (2014), s. 40-43. ISSN 1336-5835.
[5] J. Mandula, J. Urda, Degradation model of wear frogs switches on the modernization tracks. 11. Forum of rail transport, 17th to 18th March 2015, Bratislava.